

tools and jade ornaments, knives, hatchets, arrow-heads, armlets, rings, and a multitude of stone seats and idols.

Let us hope that Mr. Hartman may follow up his good and useful work by an exploration of the north-western slope of the country which has been the scene of his labours. GEORGE EARL CHURCH.

PROGRESS IN AËRIAL NAVIGATION.

THE problem of aërial navigation has been attacked by direct methods for so many centuries that the results of the recent aëronautical competition at St. Louis can scarcely be regarded as a matter of surprise. It is doubtful whether the offering of large prizes for the achievement of a result which has been attempted for years without success is the best means of promoting progress. As will have been learnt from the daily Press the great prize of 20,000*l.* was not even competed for, and a much more useful purpose would have been served by a systematic and organised attempt to encourage, by means of prizes, investigations calculated to throw an indirect light on the general question of aërial navigation, such, for example, as improvements in the efficiency of propellers, diminution of the angle of gliding of gravity-propelled machines, reduction of air-resistance of motor-propelled balloons, solution of the difficulties connected with longitudinal stability, especially in gliding machines travelling at low speeds, and what is still more important, the discovery of new results in any direction whatever calculated to open up fresh methods of approaching the whole question.

If we chronicle merely the attempts that have successfully been made in striking out on new lines, leaving out of account improvements subsequently made on the same lines, and also omitting early attempts such as those of Dante of Perugia and Le Bris, a history of aërial navigation will be summed up in the following short list:—(1) Montgolfier's discovery of the balloon; (2) application of mechanical power to the propulsion of balloons by Renard and Krebs; (3) introduction of gliding experiments under gravity by Lilienthal; (4) the introduction of explosion engines and other light motors theoretically capable of maintaining a flying machine in the air. Each of these innovations has brought the goal more distinctly in view, and yet experiments so far have left a wide gap between the results of actual performance and what is necessary to render aërial navigation practically useful. The special difficulty connected with aërial navigation is that it is not easy to see how to approach the problem except by direct methods of attack, while the great majority of scientific discoveries have been made indirectly as the result of observations originally undertaken for some entirely different object that has been known from the very outset to be possible of attainment.

By analogy with fishes and birds, respectively, the two forms of machine experimented on, involving as they do the use of gas bags and aëroplanes or aërocurves, might not inappropriately be described as the aërial swimming machine and the flying machine proper. It is somewhat remarkable in the face of natural evidence that the swimming machine has up to the present proved by far the most tractable of the two, and has undoubtedly led to the best results. It is the safest to experiment with. That accidents have frequently occurred is perfectly true, but they have all been attributable to causes not beyond the ken of an ordinary practical but intelligent mechanic.

Of aërial swimmers constructed within the last few years the most notable ones are undoubtedly the

Santos Dumont series, the ill-fated De Bradski airship, the Lebaudy, Barton, Spencer, Baldwin, Benbow, Beedle, and Deutsch forms. A few details of these, collected for comparison, may be of interest.

M. Santos Dumont's No. 7 is 160 feet long and 23 feet in diameter, and is provided with a four-cylinder motor capable of developing 60 horse-power and making 1200 revolutions per minute. Its predecessor, No. 6, was 108 feet long and 20 feet in diameter, with a motor of 16-20 horse-power. This was the machine which won the Deutsch prize, and its speed relative to the air was probably about 19 miles an hour. No. 7 was originally intended to compete at St. Louis, but M. Santos Dumont did not enter.

The De Bradski airship is now a thing of the past. It was 111 feet long and weighed about 1923*lb.*, and a special feature was that the machine was not *quite* light enough to raise itself, the ascent being effected by a screw revolving in a horizontal plane. The experiment ended in October, 1902, with a fatal accident, the airship becoming unmanageable, and the car breaking away owing to the weakness of its supporting wires.

The experiments of MM. Lebaudy have been remarkably successful in spite of an accident which destroyed their first machine in November, 1903. This did not deter these indefatigable aëronauts from constructing, partly out of the wreckage of the old one, a new machine of the following dimensions:—Length 58 metres, greatest diameter 9.8 metres, volume of gas 2600 cubic metres, or about 94,000 cubic feet; motor, a four-cylinder Daimler of 40 horse-power running at 250 to 1200 revolutions per minute; propellers, two screws 2.44 metres in diameter running at 800 to 1000 revolutions per minute. Of the thirty voyages made with this "aërial cruiser" in 1904, the following appear to have been the most successful:—August 16, a distance of 16 miles in 41 minutes; November 22, a run of 1 hour 33 minutes. An accident occurred on August 28 owing to the "swimmer" breaking loose, but it floated away to a distance and finally got caught in a wood 70 kilometres distant, whence it was brought back with slight damage. The present model is remarkably like a fish in shape, and the resemblance is further accentuated by the tail-like double horizontal rudder in the stern. The balloon has a flat base with a long vertical keel, and all these arrangements are well calculated to make it travel steadily.

Beyond the mere rumour of an accident last spring the Barton airship seems to have lapsed into oblivion of late, but it must not be forgotten that a year is small interval of time in the construction of aëronautical machines. The dimensions given are as follows:—Length of balloon 170 feet, diameter 40 feet, total estimated weight 15,700*lb.*; number of propellers, six, each consisting of six blades arranged tandem fashion, placed in pairs, one on each side of each motor; motors, three in number, developing 50 horse-power each, and running at 1600 revolutions. A peculiarity of Dr. Barton's design is the series of aëroplanes, thirty in number, employed to raise the machine. The shape of the balloon and the structure of the underlying framework and car suggest the possibility of considerable head resistance.

Of the performances of Messrs. Spencer's airship satisfactory records were given in the Press at the time. The dimensions are:—Length 93 feet, diameter 24 feet; propeller, a single screw 12 feet in diameter, placed in front; engine of 24 horse-power running at 1050 revolutions.

Mr. Baldwin's and Mr. Benbow's airships, exhibited at St. Louis, appear not to have made any

noteworthy performances, the former having failed to stem a wind of six to eight miles an hour, and the latter having made progress at the rate of three miles an hour. We have before us a brief description of the machine with which Mr. Beedle made a successful preliminary trial in November, 1903, and further trials were promised for last spring. Mr. Beedle proposed to dispense with rudders and steer by means of a screw fan in front which could be turned in any desired direction, an arrangement calculated to leave much to be desired in the matter of steadiness. The particulars are:—Length 90 feet, diameter 24 feet, horse-power 12. Of the Deutsch "swimmer" only a model was exhibited at St. Louis.

A comparison of the figures of several of these airships gives the impression that the Lebaudy balloon is far ahead of most of its rivals in its well designed proportions. The only questionable feature is the presence of horizontal rudders at the back of the car, in a place where they might prevent the stream lines of air from closing round the balloon, and thus increase the resistance. About this point MM. Lebaudy are best able to judge.

The limits of speed of the aerial swimmer attainable by existing methods are now pretty well known, and fall far short of the amount necessary to travel in the teeth of a high wind. Still, the navigable balloon offers the most promising field of experiment for those who are not prepared to devote themselves to a long course of purely mathematical and experimental researches, or to run blindfold into the dangers which such a course of study would enable them to predict.

For the successful realisation of mechanical flight proper, what is most wanted is a complete and exhaustive investigation, both by mathematical and experimental methods, of the longitudinal stability of various forms of machine gliding at various angles either under gravity alone or when mechanically propelled.

The small fluctuations of a gliding machine about steady motion are determined by exponential functions of the time the coefficients of which are the roots of an equation of the fourth degree. If these roots determine oscillatory motions there will be, not one, but two different oscillations of the machine in a vertical plane. Either of these oscillations may increase or decrease with the time, and unless they both tend to decrease the pitching will become dangerous and the machine will overturn. Photographs of the paths of gliders taken by Mr. Williams some time ago with magnesium light distinctly showed the two oscillations, and in several cases the final overturning in a manner perfectly consistent with theory.

Now it is possible to determine experimentally for any given machine the coefficients of stability when gliding at every different angle. To do this it would be necessary to measure, by means of dynamometers, the force and couple components acting on either a full-sized machine or a model when moved through the air in different directions in its plane of symmetry. It is necessary also to take account of the small changes in these forces and couples when the machine has a small rotational motion, such as occurs when it is turning upwards or downwards in the course of its oscillations. These small changes may, and in all probability do, play an important part in affecting the stability. A whirling table gives exactly the kind of small rotation required in addition to the necessary translatory motion. By reversing the model experimented on, the direction of this rotation may be reversed, and the differences of the two sets of dynamometer readings will give three of the coefficients of stability.

If observations of this kind were made it would be possible to work out on paper the oscillations, and to ascertain the lowest velocity at which a machine would glide safely.

But experimenters have hitherto confined their attention to measurements of the air resistance, and very few have up to the present given much attention even to the variations in the position of the centre of pressure except for a few cases such as a square lamina. The object in most cases has been merely to find out the speed at which a flying machine would travel under favourable conditions, and not its powers of extricating itself from the most unfavourable positions which it might assume on a gusty day. "Stability of motion" is a phenomenon which rarely enters into practical problems. In the flying machine it is of paramount importance.

A similar mathematical investigation has been made by Signor G. A. Crocco in Italy, in connection with stability of airships, but the author obtains an equation of the third instead of the fourth degree. He, however, takes no account of the fluctuations in the horizontal motion, which are certainly of importance in the case of gliders.

Meanwhile the artificial balancing of gliders under gravity has been the subject of a considerable number of experiments in America, and more recently in France, and the initial success of Mr. Orville Wright in rising from the ground on a motor-driven machine in the face of a wind and landing safely constitutes the first achievement of an actual flight. It is a matter of congratulation that Mr. Wright was not so emboldened by his success that he became reckless, and pushed the experiments on to a premature end.

The large curved surfaces of the disastrous Lillenthal and Pilcher experiments have now given place to a pair of narrow superposed rectangles, first introduced by Chanute and Herring. The tail has since, in the hands of Messrs. Wilbur and Orville Wright, been replaced by a front rudder, and the adoption of a horizontal position "*à plat ventre*" shows that the maintenance of balance has been reduced to a matter of steering.

These types of gliders have been taken up in France by Captain Ferber, of the Artillery, and subsequently by Mr. Ernest Archdeacon, both of whom have become enthusiastic "aviators," and have in their turn brought gliding experiments into considerable popularity in that country. As Captain Ferber remarks, a sloping hillside with a wind blowing straight up it are necessary, and a convenient experimenting ground has been found at Meudon. With the object of experimenting on larger motor-driven models Captain Ferber constructed an *aërodrome* consisting of a column eighteen metres high, supporting a rotating beam thirty metres across. This apparatus would be very useful for determining the stability coefficients of an actual machine firmly attached to its beam, but it must not be forgotten that any kind of suspension may seriously modify the longitudinal oscillations. So, too, may the rotation about the vertical axis; it is much easier to make a glider describe a corkscrew path than glide in a straight line. A kite illustrates the same properties. Its oscillations also depend on a biquadratic equation, but the supporting string modifies their character, and Mr. Cody claims that a man has been lifted 1600 feet by kites, though how the *photograph* of "the Cody man-lifting kite 800 feet high" was taken, which appears in the *Aëronautical Journal*, is not explained. The use of kites for saving life at sea might well receive more attention than has been bestowed on this question up to the present. The clumsy plan of sending up rockets in the teeth

of a gale such as would just blow a kite line from ship to shore needs reconsideration.

Little has been published about Prof. Langley's experiments beyond a reference to the accident which gave Prof. Manley a premature bath in the Potomac.

The idea of combining a glider and boat was tried initially with success and ultimately with failure by Herr Kress on a reservoir a few miles out of Vienna, near the main railway line from Germany. Major Baden-Powell has adopted the same plan at the Crystal Palace. The machine descends a kind of chute from a height of about thirty feet, and is shot off into the air about six feet above the water. With this small height it is not unlikely that successful glides might be made even if the steady motion were longitudinally unstable, for by careful projection several wave-lengths might safely be described in the air before the pitching became dangerous.

It is probable that a motor driven machine travelling at high speed would be much more stable than a gravity machine, but to understand the management of the machine is a necessary condition of success, and the more this can be made the subject of mathematical study the easier will the task be for an aeronaut who is perfectly familiar with the equations of motion. In regard to the effect of speed on stability, the pretty butterfly-like "helicoptera" driven by elastic must not be quoted as instances. They raise themselves nearly vertically; we are concerned with machines moving nearly horizontally.

From all that has been said above it will be seen that there is plenty of work to be done in connection with aerial navigation. At the present time, careful quantitative measurements of the coefficients of stability of actual machines by attaching them to whirling tables are even more needed than further balancing experiments in mid-air.

G. H. BRYAN.

PHAISTOS AND HAGIA TRIADA, CRETE.

IN the south of Central Crete, a day's journey from Candia on a good horse, lies the scene of discoveries no less important than those of Dr. A. J. Evans at Knossos. They consist of the ruins of two palaces, one large and one small, but both built on the same general plan and with the same materials (stone and concrete) as that which has made Dr. Evans famous. There can be no doubt that all three belong to one age and one social system; that they were under one Government is clear from the fact that none of the three were fortresses. Crete was, in fact, as Thucydides told us long ago, a sea-power which had no fear of assault by land. With the architectural or historical interest of these remains we need not concern ourselves at present, nor with the general character of the articles found in them. In all three we meet with vessels of use and ornament, painted frescoes, inscribed blocks or tablets, seals, human and animal figures, and articles of domestic or religious character. But in or near Hagia Triada there came to light a number of objects of special interest which distinguish that palace, smallest of the three, above the others.

First there is a sarcophagus of stone, painted upon all four sides. Each of the two ends bears a chariot in which are two female figures; a pair of horses draws one, a pair of griffins the other. The two sides bear a representation of sacrifice to the dead. Men leading animals—bull, goat, or sheep—women with baskets of fruit, others with bowls apparently full of wine or some other liquid, which is being poured into a large jar; a flutist and a harper, playing upon

a lyre of seven strings (which are therefore older than Terpander by a thousand years); men carrying animals in their arms; and lastly the dead man himself, standing beside a tree before his own tomb and receiving the pious offerings. A most noteworthy fact in this representation is that the men wear women's skirts.

Next come three vases of steatite, each bearing a scene carved in relief. The workmanship of these carvings is astonishing for its finish, and the designs are full of life, reminding us not distantly of good Attic work. On one vase a couple of youths stand face to face, one leaning upon a spear or staff, the other bearing over his shoulders a staff and a whisk of some sort. Both are naked, save for the familiar loincloth of the Mycenæans (which the Greeks never wore, except in the very earliest times at the Olympian games), and high boots of the same kind which are still worn in Crete and always have been. The second vase represents several pairs of men, some wrestling and some boxing, and a bull-hunt or bull-baiting. The boxers have their hands bound about with straps of leather, or something like a fingerless glove. Some of these men wear helmets, which in part at least seem to be made of metal; and helmets hitherto have been undreamt of at this period.

But the last vase is the most striking of all. It bears a procession of men marching two and two, led by a personage clad in a stiff bell-shaped tunic covered with scales. He is bareheaded and carries a long staff or sceptre resting upon his shoulder. The men behind him wear flat caps something like to a turban, and loincloths, and each carries over his left shoulder a long pole branching out into three long flexible wands at the end. In the middle of the procession are four men singing, one bearing the *sistrum* of Isis; these have no wands. Some see in this a triumphal procession of soldiers after war. The lack of arms or shields makes this unlikely; the three-pronged objects can hardly be weapons, for they seem to be flexible, but what they are it is impossible to say. Those are more likely to be right who believe it to be a harvest festival of some kind, and the three-pronged implement an implement used in some harvesting process. If we may assume that these objects have no use at all, but are ornamental (which is not likely), the whole might be a religious procession without regard either to war or husbandry.

NOTES.

THE Bakerian lecture of the Royal Society will be delivered by Dr. Horace T. Brown, F.R.S., on March 23, upon the subject of "The Reception and Utilisation of Energy by the Green Leaf."

It is proposed to erect in Jena a memorial to Prof. Ernst Abbe, so that all who see it may be reminded of his great services to optical science and industry, and his sterling qualities as a man. Abbe's work and influence are appreciated wherever physical science and sociology are studied, and there should be no difficulty in obtaining sufficient funds to raise a noble monument to his memory. The committee organised for this purpose includes the names of Dr. Czapski, Dr. Eggeling, Dr. G. Fischer, Prof. Rosenthal, and Prof. Winkelmann. Subscriptions for the memorial should be sent to the treasurer, Dr. Gustav Fischer, Jena.

Science states that the Prussian Academy of Science has awarded its Helmholtz medal to Prof. Ramón y Cajal, professor of neurology at Madrid.